

FRACTURES OF THE VERTEBRÆ.¹

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IN a review by Dr. Rieder of cases of spinal surgery treated in the Hamburg City Hospital (quoted by Lloyd, *ANNALS OF SURGERY*, Vol. xvi, September, 1893), the cases were grouped as follows:

- (1) Injuries to the spinal cord without injury to the vertebræ.
- (2) Injuries to the spine treated without operation.
- (3) Injuries to the spine operated upon.

As an illustration of the first group, an instance is cited when a fall of fifteen feet upon the head resulted in anaesthesia of both lower extremities and trunk as far as the cervical vertebræ, with diminished sensation and muscular power of the upper extremities. There was violent pain in the neck and extreme sensitiveness to pressure over the cervical vertebræ, but no demonstrable dislocation or crepitus. The patient died in twenty-four hours in collapse accompanied by unconsciousness, meteorism, and dyspnea. The autopsy revealed a rupture of the ligaments between the vertebral arches of the first, second, fourth, fifth, and sixth cervical vertebræ, with anterior luxation of the sixth and posterior dislocation of the seventh cervical vertebra, with rupture of the intervertebral cartilage. The cord was lacerated between the third and seventh pairs of cervical nerves, and there was hæmorrhage into the canal.

Of the five cervical cases treated without operation, the first one could not have been cured or improved by operation. Twelve days before admission to the hospital, the patient jumped headlong into the water and struck his head on the bottom. There followed immediately complete motor and sensory paraplegia, repeated vomiting, difficulty of swallowing, attacks of dyspnea, incontinence of feces and urine. Slight prominence of the first

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dorsal vertebra was observed. The autopsy revealed slight prominence of the fifth cervical vertebra; a piece of bone broken off and connected with the sixth cervical vertebra; cervical cord extremely soft and sunken in the region of the fourth and fifth roots; a cavity bounded by the pia mater anteriorly, and by a thin layer of cord tissue posteriorly, filled with necrotic shreds.

The second case treated without operation would have terminated fatally under any treatment. The injury was caused by a fall of fifty feet, resulting in fracture of the fifth and sixth cervical arches, with dislocation of the sixth upon the seventh cervical. There was a slight extravasation in the dural sac in the cervical and dorsal regions and complete destruction of the cord between the fourth and seventh nerves. In addition to the usual symptoms, the patellar reflexes were weak, and there was slight priapism.

The third case treated without operation might have been relieved by immediate operation. A piece of bone chipped from the anterior circumference of the sixth cervical vertebral body caused a wedge-shaped compression of the cord. The usual symptoms of cord compression were observed.

In the fourth case the injury consisted of a complete crush of the body of the sixth cervical vertebra. The ligaments between the vertebrae were not lacerated. The cervical portion of the cord from the point of fracture up to the third cervical vertebra was changed into a white paste, in which white and gray substances could no longer be distinguished. There were other injuries in this case, but the condition of the cord was such that no improvement could have resulted from an operation.

In the fifth case the patient was injured by being bent backward. There was slight tenderness on pressure over the sixth and seventh vertebrae, loss of motion and sensation in the lower limbs, and anesthesia extended to a line somewhat above the nipples. The reflexes were increased; the rectum and bladder paralyzed. There was in this case fracture of the bodies of the sixth and seventh cervical vertebrae, with rupture of the ligaments and crushing of the spinal cord. Operation would in all probability have availed nothing.

Six cases of fracture of the dorsal vertebrae were not operated. In the first there was a transverse fracture and dislocation backward of the body of the twelfth dorsal vertebra, with total

paraplegia and anæsthesia of the legs and trunk to the umbilicus. The patient lived six months. At the autopsy an ascending degeneration of the column of Goll, with chronic myelitis and atrophy of the lumbar cord, was found.

The second case consisted of a fracture of the dorsal body, with posterior dislocation of the lower fragment, and a detachment of a piece of the posterior part of the body of the eighth dorsal. There was complete destruction of the cord at the seat of injury. The reflexes were absent. Operation would probably not have benefited the patient.

In the third case there was crushing of the fifth dorsal with other injuries. The spinal cord was torn across at the seat of the spinal injury, and the patient died immediately after admission to the hospital. Operation would not have benefited this patient.

In the fourth case there was complete paraplegia in both legs and almost symmetrical anæsthesia as high as the umbilicus. The spinous processes of the fifth, sixth, and seventh dorsal were prominent and tender. At the autopsy the ninth dorsal body was fractured and a wedge-shaped piece was dislocated into the vertebral canal, so that the spinal cord was completely severed and the canal blocked.

The fifth case was one of direct violence, the patient being struck in the back while lying on the ground. There resulted a fracture of the sternum and fourth dorsal vertebra, which was dislocated backward, contracting the lumen of the canal. At the autopsy the cord was found softened at this point. Under extension and counterextension the anæsthesia finally disappeared down to the soles of the feet, but reappeared together with paralysis of the rectum and bladder. Patellar reflexes had disappeared.

In the sixth case there was fracture of the eighth and ninth dorsal vertebrae. The right leg and arm were paretic, but sensation was normal. The left arm and leg were normal; reflexes normal; bladder paralyzed. After the application of a plaster-of-Paris jacket, the bladder paralysis disappeared. The right arm also recovered and the leg greatly improved. The patient was dismissed from the hospital much benefited.

Some of the cases reported under the group, "Fractures of the Vertebral Column treated by Operation," are interesting.

A male aged twenty-four years fell on his back from a wall. Shock, copious bleeding from the left ear without injury of the

skull, fracture of the fifth and sixth dorsal vertebræ with deformity, complete paraplegia of motion and sensation from the umbilicus down, paresis of bladder and exaggerated reflexes, followed the accident. The patient was treated by extension and counter-extension, and finally by a plaster-of-Paris corset. There was a progressive increase in symptoms under this treatment, and in about a year after the accident the fifth and sixth spinous processes and vertebral arches were resected. Some fragments of bone pressed upon the cord. No injury to dura or cord was made out. There was no improvement, and the patient died two years after the accident.

At the autopsy the vertebral canal was found closed by fibrous tissue. The spinal cord was compressed and its structure on section was not recognizable.

The second case was that of a male struck on the left shoulder by a heavy block of wood. The accident was followed by the usual symptoms of injury to his cord. The patient was treated by extension. Ten days later he could move the toes of the right foot slightly. There was hyperæsthesia and feeble power of rotation. There was still further improvement, but at the end of a year his condition became worse. Careful electrical treatment failed. A year and three months after the injury four spinous processes and arches were removed in the mid-dorsal region by means of the chisel and mallet. The cord was almost completely destroyed, the fractured body of the sixth dorsal being pressed into the canal. There was an increase in the spastic symptoms lasting for some days after the operation, but no improvement. An immediate operation might have been of value in this case.

There is recorded a case of simple fracture of the laminae of the last two dorsal and first lumbar vertebræ, the bodies also being crushed. Laminectomy was performed seven months after the injury. Four years later good use of the lower extremities was reported and no anesthesia existed above the knees. (J. A. Wyeth, April 18, 1891.)

August, 1894, John A. Wyeth (*ANNALS OF SURGERY*, August, 1894) reported five cases of vertebral fracture. The first case was that of a male, aged twenty-one years, who was thrown from a locomotive, striking the rail and bounding from the track. The patient had lost all power of motion from the pelvis down. The paralysis involved both rectum and bladder.

There were severe pains in the legs and feet. Eight months after the accident, Dr. Wyeth performed laminectomy of the last two dorsal and first lumbar vertebrae. The bodies of these vertebrae were crushed in such a manner that the cord was partly divided, and the undivided part was compressed between the laminae of the vertebrae above and the crushed and displaced body below. The compressing bone was removed and the dura closed. Slight improvement in motion was immediate, especially in the feet. The improvement continued, and in four years the patient had good use of the lower extremities; could flex and extend the thighs and legs; anaesthesia had disappeared above the knees. The patient, however, had to use a cane or crutch in locomotion.

The second case was that of a patient ten years old, who, at the end of four months, still suffered paraplegia of motion and sensation from the level of the umbilicus, and also paralysis of bladder and rectum. No improvement followed a laminectomy of the sixth, seventh, and eighth dorsal vertebrae. The continuity of the cord was almost completely destroyed.

The third case was that of a patient aged sixteen years, who fell twenty feet. The accident resulted in paraplegia of motion and sensation below the hips, with paralysis of bladder and rectum. Plaster-of-Paris jacket was employed for six weeks. Eight months after the date of the accident, laminectomy of the eleventh and twelfth dorsal and first lumbar vertebrae was performed. The cord was small and soft, but not compressed. Pachymeningitis existed. There was no improvement.

In the fourth case a .38-caliber ball entered to the right of the spinous processes, penetrating the spinal canal through the right laminae of the third and fourth dorsal vertebrae. The usual symptoms of injured cord followed. Dr. Wyeth saw the patient seven months after the receipt of the injury and operated two days later. The bullet had cut the dura and the cord on the right side, and passed into the body of the vertebra. Some spiculae were removed, but there was no improvement in the paralysis.

The result of laminectomy sixteen hours after the accident is shown in the third case. The patient, a male aged thirty-four years, fell two stories. There followed complete paraplegia of motion and sensation; absence of patellar reflexes; deformity of fifth and sixth dorsal vertebrae; priapism; distention of blad-

der with urine. The next day incipient bed-sores over gluteal region were noticed. The operation was performed under chloroform-morphine narcosis. The spinous process of the fifth dorsal was found fractured and removed. The arch of the sixth vertebra was broken in its posterior section. The fractured piece, together with the whole posterior segment, was driven into the vertebral canal and materially reduced its lumen. The fractured spinous process had advanced under the skin, and the upper portion of the fragment was found lying upon and compressing the cord. This fractured arch was removed and the cord left free and surrounded by the uninjured dura. Two days later improvement began. Patellar clonus was noted on both sides. Plantar reflexes greatly increased on left side, the whole extremity responding violently, less intensely on right side; sensation not changed; functions of bladder and rectum normal. The patient was eventually on his legs all day, could walk for two hours without fatigue, and, according to his own statement, enjoyed at home excellent health.

I find reports of two cases of laminectomy for fracture of the laminae of the first three lumbar vertebrae. (Dr. W. C. Arnison, Manchester, England.) In the first case operation was performed four weeks after the receipt of the injury. The patient was able ultimately to walk out of the hospital.

In the second case the operation was performed seven days after the injury. Great improvement in his general condition and a slight increase of muscular power resulted. (ANNALS OF SURGERY, January, 1897.)

In another case (Dr. E. P. Riggs) operation was performed four days after the injury for fracture of the laminae of the last dorsal and first two lumbar vertebrae. Result: Sensation as far down as the knees; each foot can be slightly moved. (ANNALS OF SURGERY, January, 1897.)

Dr. W. L. Pyle reported the performance of laminectomy for fracture of the first lumbar arch six days after the injury. Girdle pain disappeared; general condition good; bed-sores healed, but there was no improvement in the paralysis. (ANNALS OF SURGERY, January, 1897.)

Dr. J. A. Romeyn gives four cases of entire recovery following laminectomy for fractured lumbar vertebrae. (ANNALS OF SURGERY, January, 1897.)

Six weeks after a fall followed by the usual symptoms of fractured vertebrae, a patient, aged fourteen years, entered the hospital for operation. Several days subsequent to the accident, he had chills with high temperature. During part of the time there were many fluctuations of temperature. Two weeks later a laminectomy of the eighth, ninth, tenth, and eleventh dorsal vertebrae revealed a layer of lymph an eighth of an inch in thickness. This was followed as far as the canal was exposed. The dura was incised four inches and a considerable quantity of cerebrospinal fluid escaped. The cord was not bruised or divided, but seemed smaller than normal. The fluctuations of pulse and temperature persisted to the end. The urine was ammoniacal and contained pus. There was no improvement. (Dr. J. A. Wyeth.)

A young adult was admitted to St. Luke's Hospital, Chicago, March 26, 1903, suffering from fracture of the fifth and sixth cervical vertebrae. He had complete paralysis of all the parts below the injury. The reflexes were abolished. Laminectomy of the fifth and sixth vertebrae was performed by Dr. W. H. Allport. The dura was torn about an inch. The cord was explored and no marked laceration discovered. The wound was sutured, gauze drainage being employed. The patient died March 29, laboring under great dyspnoea.

These cases have an important bearing on the subject of early operative interference.

While both early and immediate operations are more strongly recommended than formerly, even late operations are not always followed by negative results.

Dr. Oscar J. Mayer (ANNALS OF SURGERY, August, 1897) reports a case of laminectomy sixteen months after fracture. The patient had paraplegia of motion and sensation of the legs. He had to be catheterized, and the bowels were constipated. The bowels moved on the third day as the result of a purgative, but unconsciously. Patient was encased for seven weeks in plaster of Paris extending from the arm-pits to the toes. The only complaint at this time was pain in the bladder, especially during

irrigation. Upon the removal of the plaster, decubiti were observed on scapula, sacrum, heads of fibula, and both heels. The condition of the patient when finally admitted to the hospital was as follows: Spinous processes of first and second lumbar displaced to right and painful; incontinence of urine and feces; paralysis and atrophy of lower extremities; only slight movement at hip-joint; knee- and ankle-joints more or less ankylotic.

Percussion of the quadriceps tendon caused clonic contraction of the muscles of the thigh, throwing the whole leg into vibration. There was livid discoloration of legs. At the end of May the patient could, with the assistance of furniture, move a few steps around the room. He could not sit on a chair on account of the ankylosis of the knee-joint. Cystitis improved; incontinence of urine and feces persisted. At the end of June the patient could so use his thighs that he could throw his legs forward, and was able to insecurely stand and walk a few steps with the aid of crutches. Laminectomy, September 6, 1895. The laminae of the first and second lumbar showed a decided recession from the normal. The dura was found adherent to the cord. After fifteen days, the patient for the first time asked for a vessel; the bowels responding to voluntary effort. Incontinence of urine continued. October 8 patient showed more control of leg movements. He left the hospital with portable urinal and used the crutches fairly well; November 27 walked with the aid of one stick; could hold urine an hour and voluntarily void it. The next few months improvement continued; could hold urine three or four hours; walked several miles; could walk up and down stairs without support, and later he was able to resume work. Patellar reflex and ankle clonus absent on both sides; plantar reflex exaggerated. It is reported that the symptoms enumerated before the operation, which have since disappeared, are the following: Spastic paraplegia; incontinence of urine and feces.

Under the head of late operations, I might refer to one of my own cases in which the operation was done over a year after the injury on account of severe pain emanating from the seat of the injury. Laminectomy in the dorsal region was performed with a relief of pain, but there was none whatever of the paraplegia of motion and sensation.

Dr. E. H. Dawbarn in October, 1894, reported the complete

recovery of a case of laminectomy for simple fracture of the neural arches of the eleventh and twelfth dorsal vertebrae, performed two and one-half years after the injury.

An operation was performed in a case of fracture of the first three lumbar vertebrae two years after the injury. There was only improvement in the cystitis and bed-sores. (Dr. W. C. Arnison, Manchester, England.)

Symptoms of fracture of the laminae are sometimes obscure and the diagnosis proportionately difficult. In a majority of cases there is a history of direct or indirect violence. The deformity is sometimes very slight. Occasionally it does not become apparent for some days. In some cases several weeks, and in others again a number of months, elapse before deformity appears. (Stanly.)

Certain sounds may be elicited at times by carefully changing the position of the patient, the hand being applied to the injured part. The spinous processes may be out of line and lateral mobility of the spines may be discovered. Obvious lesion of the spinal cord is more or less convincing. (Thornburn.)

Dr. Allen Starr (*American Journal of Medical Sciences*, July, 1892) discusses in a very interesting manner the subject of local anesthesia as a guide in the diagnosis of lesions of the lower spinal cord.

"The study of motor disturbances, including the form of paralysis and of the variations in reflex activity, has made it possible to determine the situation of lesions in the spinal cord with some exactness. The level of the cord at which the various reflex actions are performed is quite well known, but the spinal cord has sensory as well as motor functions; and it is only within a short time that the disturbances in sensation occurring in spinal lesions have been utilized for purposes of diagnosis."

"It is not enough to ask the patient whether he feels the touch of cotton wool, or the tip of the finger, or the warm or cold test-tube, or the prick of the needle, or the sting of a faradic brush, nor is it sufficient to touch two parts exclusively. He should

always be tested upon two surfaces simultaneously and asked if any difference is felt between sensations."

Starr shows that a limited area of anæsthesia is produced by a limited lesion in the spinal cord; that as the lesion ascends the cord from its lowest limit upward, the area of anæsthesia extends in a different manner upon the surface of the body, and that the situation and shape of the area of anæsthesia are positive indications of the level of the lesion in the spinal cord. These facts are not wholly new.

"Situation of the anæsthesia in lesions of the lower part of the cord is such as to escape attention unless searched for; and as the patients lie in bed upon their backs and sensation is often preserved in the front of the legs and thighs, the examiner, being content with the investigation of these parts, is misled in supposing that there is no anæsthesia."

Starr reports six cases in which limited areas of anæsthesia aided the localization of the lesion.

He draws the following conclusions:

"As the location of the centres of control of the bladder and rectum appear to be uniformly affected together, they must be adjacent to one another."

"The control of the sphincters is lost when the lesion involves the lower three sacral segments, and the centres probably lie in the lower two segments of the cord."

"When these segments are destroyed, the sphincter of the rectum is relaxed, and there is no opposition to the introduction of the finger into the anus."

"The entire rectum also loses its power of contraction, so that it is only emptied by a pressure from above or by artificial evacuation."

"As soon as a few ounces of urine collect in the bladder, pressure overcomes the slight resistance of the sphincter, and the urine flowed away."

"If, in a case of paraplegia, the mechanism of the bladder and rectum is not interfered with, these organs empty them-

selves naturally when full, in spite of or without the knowledge or control of the patient, it is a proof that the lesion has not destroyed the lower sacral segments of the spinal cord. In such cases the exact area of anesthesia should be carefully determined."

He emphasizes the importance of determining the distribution of anesthesia in lesions of the lower part of the spinal cord. He shows that, as the cord is invaded by disease from below upward, the area of the skin, which becomes anæsthetic, increases in extent, and that the shape of the area is characteristic, so that from the study of the area, the extent of the lesion can be determined, and he draws attention to the value of a careful study of the disturbances of sensation in the diagnosis of the situation of lesions in the spinal cord and cauda equina.

The injuries under consideration when located below the first lumbar vertebra, and when the traumatism involves only the cauda equina, seem more amenable to treatment than those above.

Like the nerves of the periphery, those of the cauda equina are resistant to traumatism. Whether compressed or divided, they recover as soon as the compression is removed or the severed ends united. Delayed operations are likewise here followed by better results. (ANNALS OF SURGERY, July, 1896. Samuel Lloyd.)

Physiological evidence is in favor of regeneration of the nerve roots of the cauda equina. The absence of spontaneous recovery indicates the pressure of a mechanical obstacle to recovery. Some cases will recover spontaneously,—cases, probably, where there has been no extensive tearing of the roots. Thorburn is of the opinion that we should not operate here too early, say at the end of six weeks, if there has been little or no recovery, or if recovery has ceased. Too long a delay will result in secondary degeneration, which of course impairs the prognosis.

Recoil seems to be of much more frequent occurrence than is generally supposed. In a series of experimental frac-

tures in twenty-four children and eight adults, where the cord was either badly contused or entirely severed, the bones were found in place.

Post-mortem examination has shown that in two or three days after injury myelitis sets in and probably sclerosis, and in three or four months the cord has been converted into cicatricial tissue. This would favor early operation.

It is said that in favorable cases improvement begins by sudden and almost immediate return of sensibility. Motor repair is slower, but progressive from above down.

In reference to technique, Dr. Wyeth employed the following:

A free incision just over the spines, division of the attachments close to the bones with scissors or elevator, strong retraction, and iodoform-gauze packing to arrest bleeding. When well exposed, the laminae are gnawed away in bits, first by a round rongeur, and when an opening is effected, by the more rapid cutting fenestrated rongeur. After an exposure of the full length of the injured region, and all bleeding stopped, the dura is carefully punctured, and as the first few drops of cerebrospinal fluid escape, the grooved director having been inserted, the dura is split open in the middle line. This membrane should be closed by a continuous catgut suture. A wick of iodoform gauze running from the dura out of the lower angle of the wound is inserted; dry dressing over all. His cases healed without suppuration. The outflow of cerebrospinal fluid continued from two to four days in all but one case, in which it leaked out for several weeks.

The question of deliberately opening the dura in all cases is questionable.

Chipault has called attention to one sign which indicates the integrity of the meninges, viz., the motion in the dura depending upon the pulse and respiration. The absence of this, in addition to conditions which do not now concern us, indicates a ring of adhesions between the membranes and the cord, shutting off the circulation of the cerebrospinal fluid. Accord-

ing to Chipault, this pulsation is not present when the membranes have been the seat of a pathological compression either extra- or intradural; but it returns in a few minutes after the removal of the compression, if it has not been too prolonged or too intense. He looks upon the return of the pulsation as a good sign. Should it not reappear, it is because the compression has produced some intrameningeal lesion which should be explored.

There is evidence to show that surgeons seldom do a sufficiently large and complete operation. It has been my practice to satisfy myself of the freedom of the cord from compression above and below the opening made by passing a probe upward and downward, of course outside of the dura. Hemorrhage is not particularly troublesome, except in the cervical region, which in one instance was followed by death in consequence of a lesion of the vertebral artery. Efforts should be made to preserve the periosteum, since Ollier has shown on dogs that, after a subperiosteal resection, a very good osseous canal has formed. Chipault (*Lloyd's Review, ANNALS OF SURGERY*) has observed that in five children the same result was noticed. In three it was demonstrated by palpation, and in two by a post-mortem.

Experiments have been made to determine the possibility of bringing into apposition and securing the union of the two ends of the cord. Chipault found in two post-mortem cases that the retraction of the ends and the extent of the sclerosis necessitated the resection of several centimetres, after which the lack of elasticity of the cord and the resistance of the ligaments of the pia mater oppose the approach of the healthy ends. Where, however, a recent section has been made by a cutting instrument, suture of the cord, which is in reality a suture of the membranes, is possible on the cadaver.

Improvements in results must come from prompt and more extensive operations, the removal of all portions of bone that encroach upon the cord, reduction through open wound, silver-wire suture when necessary and practicable, immobiliza-

tion, and the discontinuance of the use of the mallet and chisel in operating.

The higher the injury the greater seems to be the mortality; particularly does this apply to lesions in the cervical portion of the spine. Some deaths from hæmorrhage of the vertebral artery during operations in the cervical region have been reported.

When the lesion is high and accompanied by respiratory difficulties, anesthesia becomes not only difficult but dangerous, and several deaths from chloroform and ether have been reported.

The following conclusions seem reasonable:

(1) Laminectomy is superior to a simple reduction of the deformity, since, in fractures of the arches, reduction has no certain effect upon isolated fragments, and reduction alone has hastened death.

(2) Reduction may be more rational when effected through the open wound of laminectomy.

(3) Simple reduction is useless where there are clots or adhesions sufficient in themselves to account for the spinal disturbance.

(4) In cases of cervical luxation without fracture, simple reduction has given good results.

(5) It is possible to still further improve the prognosis of reduction in simple cervical luxations by making the reduction with the arches exposed and employing silver-wire suture of the processes to prevent relapse.

In consideration of the distressing prognosis in lesions of the cervical region, an operation appears strongly indicated.

Degeneration is observed wherever the narrowing factor is not removed.

The treatment of vertebral fractures without operation offers a chance of success only where there exists little or no disturbance of the spinal cord, such as paralysis of a single group of muscles, one-sided paralysis, or partial disturbances of sensibility, etc.

In all cases where the usual assemblage of symptoms indicate a severe alteration of the cord, only prompt operations directly afford the best chances of securing improvement or cure.

It is Dr. Mayer's opinion (*ANNALS OF SURGERY*, Vol. xxvi, August, 1897, page 218) that, upon the evidence of statistics of recent years, an operation is justified no matter how doubtful the case may appear. While the operation is essentially experimental and its results problematical, the striking cures accomplished within recent years must spur us on to the performance of an operation.